Forecasting for Environmental Flows –

What does an accurate and timely runoff forecast buy you?

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California Cooperative Snow Conference

November 15, 2018

San Joaquin River Restoration Program

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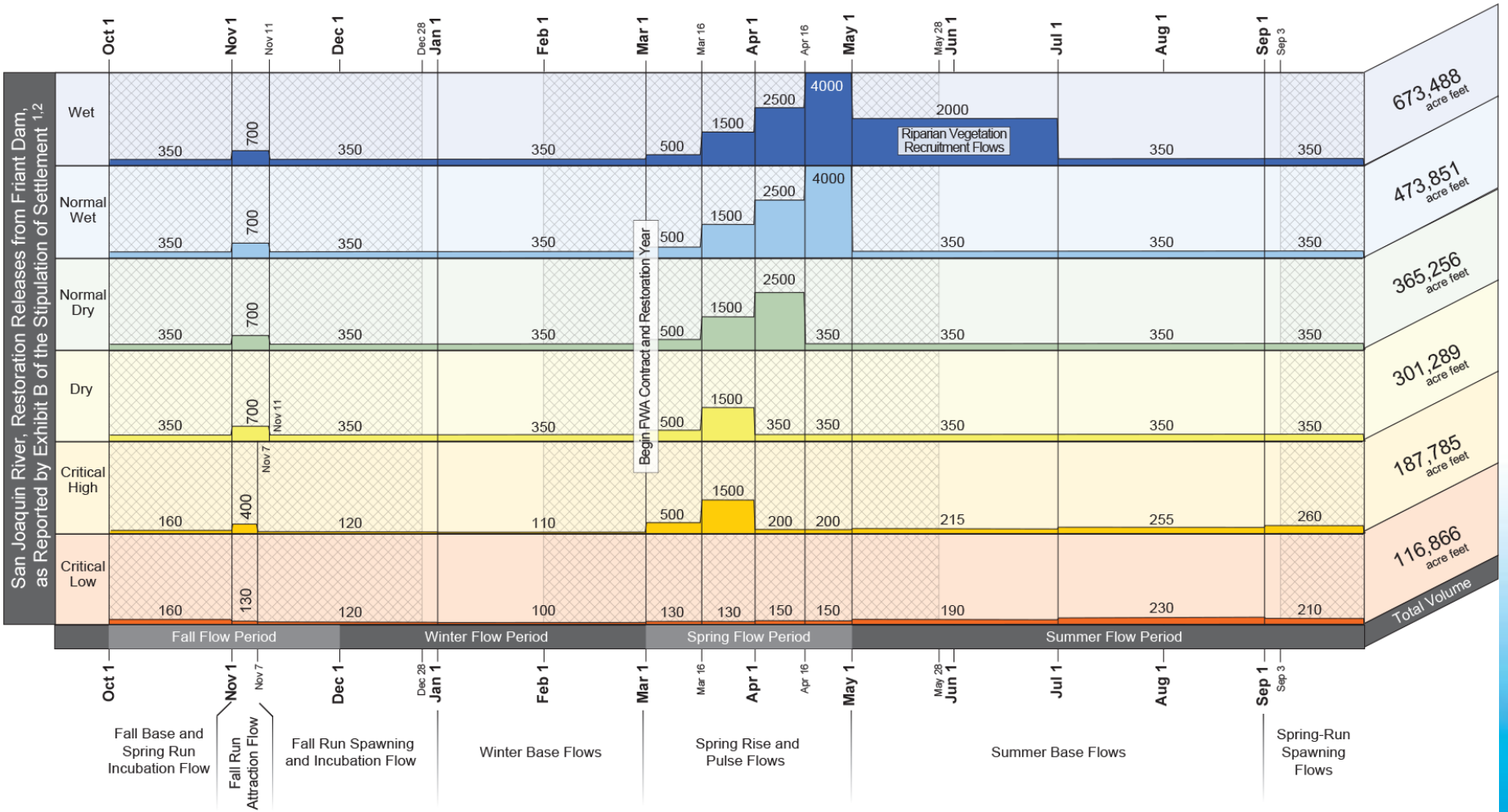
1 RESTORATION FLOW SCHEDULING

San Joaquin River Restoration Program Flow Releases

San Joaquin River, Restoration Releases from Friant Dam,
as Reported by Exhibit B of the Stipulation of Settlement[1,2]



1 - NRDC v Rodgers, Stipulation of Settlement, CIV NO. S-88-1658 - LKK/GGH, Exhibit B. September 13, 2006
2 - Hydrographs reflect assumptions about seepage losses and tributary inflows which are specified in the settlement

Spring and Fall Flow Flexibility for the Restoration Administrator

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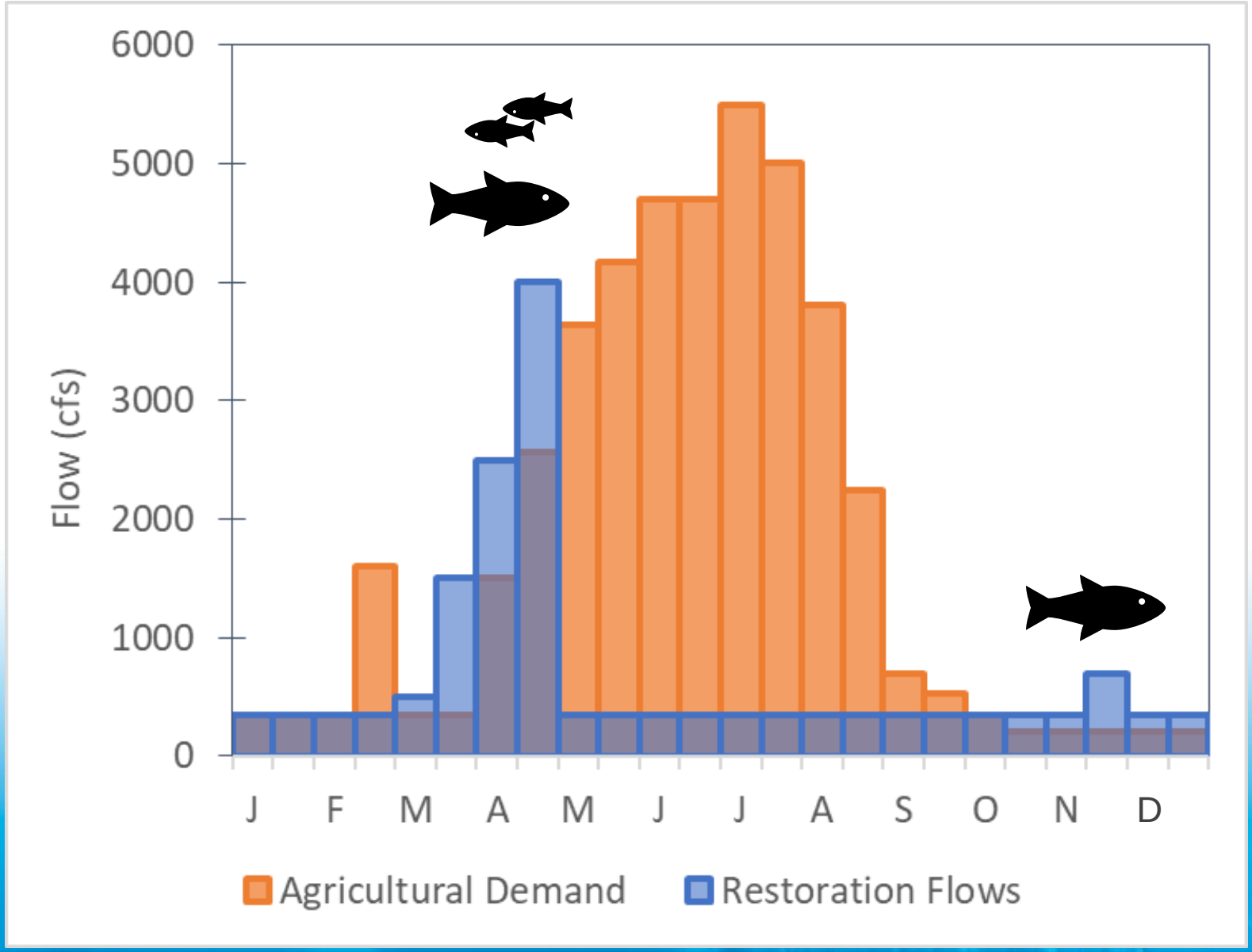
Flow Timing



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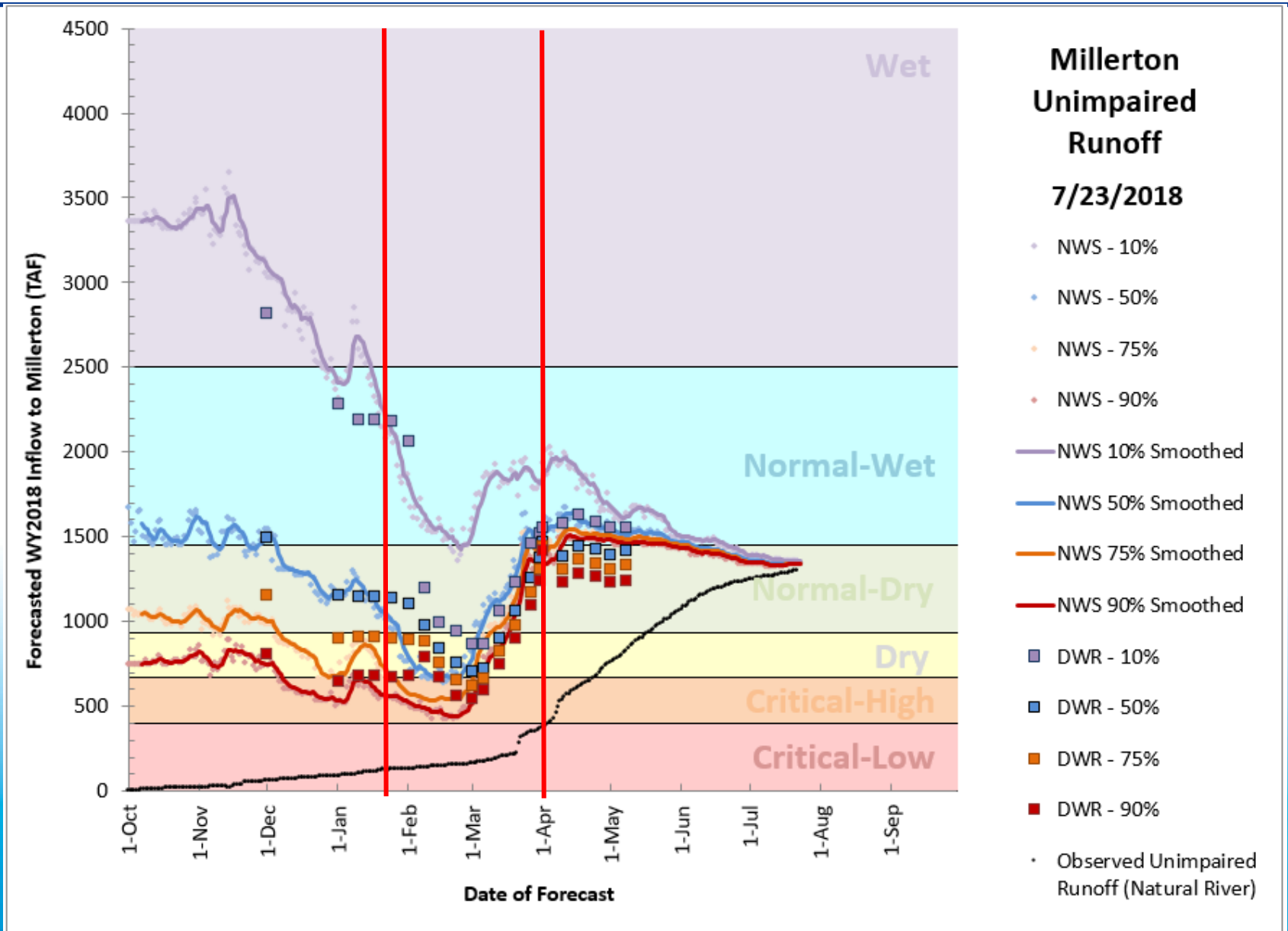
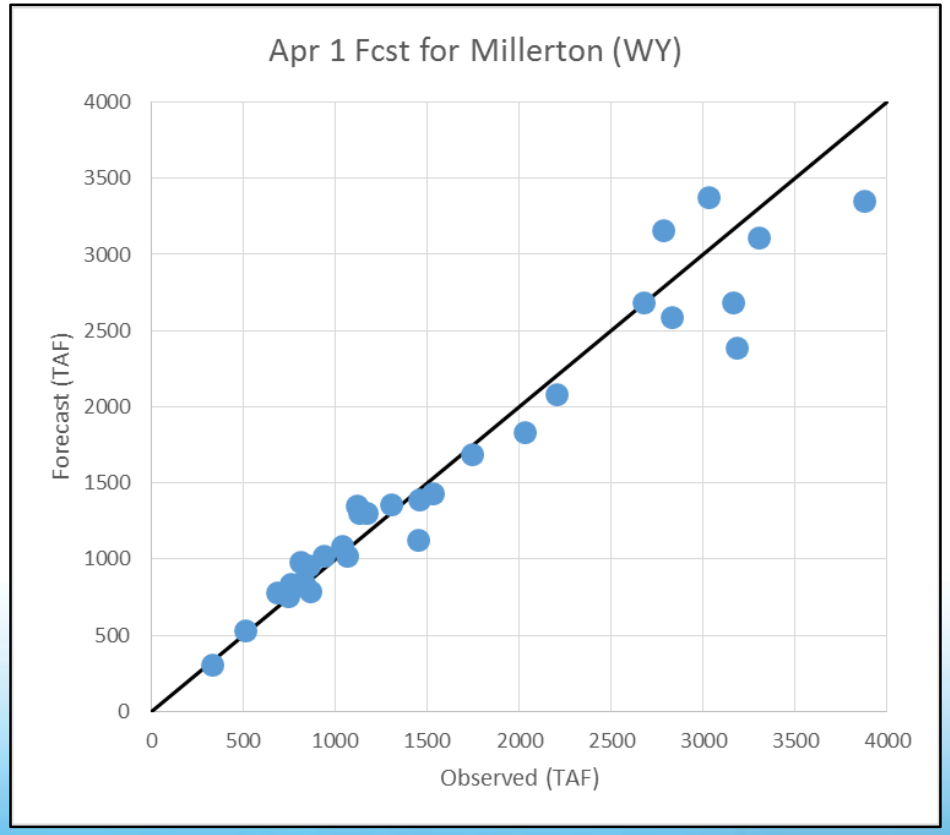
Forecast Uncertainty

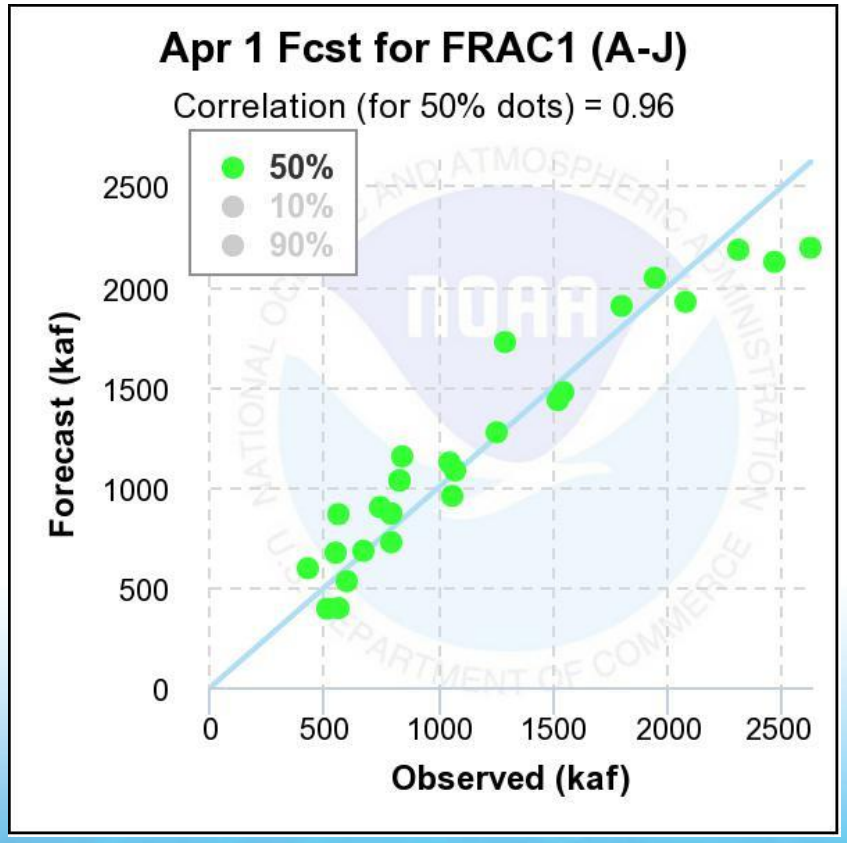


Runoff Forecast Verification

DWR Bulletin 120



NWS River Forecast Center



Forecast error for both models sometimes on the order of Millerton Lake active storage capacity ~395 TAF

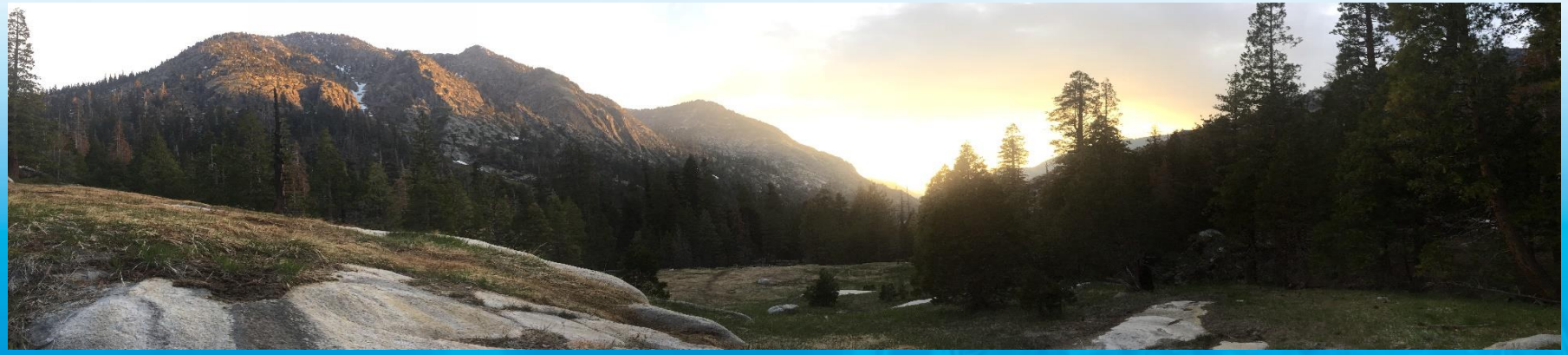
What tools can narrow the forecast spread, especially between 90% and 50%?

Restoration Flow Scheduling

Summary

- Majority of release volume for environmental flows is before most of the WY runoff reaches Millerton Lake
- Need to make decisions on biological objectives by April 1

Accurate April 1 forecasts are key to prevent over or under releases of Restoration Flows



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2 WATER TEMPERATURE MANAGEMENT

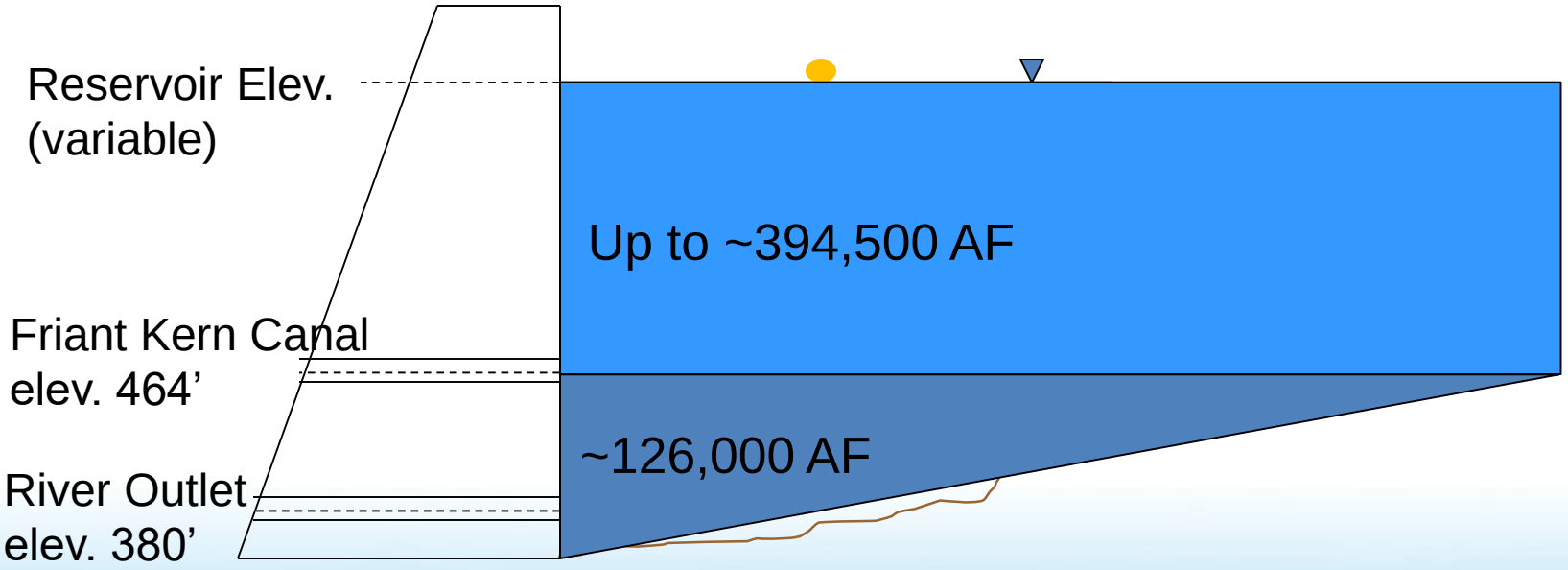
Temperature Objectives

Table 3-1.
Temperature Objectives for the Restoration of Central Valley Chinook Salmon

Monthly Water Temperature Objectives for the San Joaquin River Restoration Program												
Spring-Run and Fall-Run Chinook Salmon												
Life Stage	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Adult Migration			Optimal: ≤ 59°F (15°C) Critical: 62.6 – 68°F (17 – 20°C) Lethal: >68°F (20°C)									
Adult Holding (Spring-Run Only)				Optimal: ≤55°F (13°C) Critical: 62.6 – 68°F (17 – 20°C) Lethal: >68°F (20°C)								
Spawning								Optimal: ≤ 57°F (13.9°C) Critical: 60 – 62.6°F (15.5 – 17°C) Lethal: 62.6°F or greater (17°C)				
Incubation and Emergence								Optimal: ≤55°F (13°C) Critical: 58 – 60°F (14.4 – 15.6°C) Lethal: >60°F (15.6°C)				
In-River Fry/Juvenile	Optimal: ≤60°F (15.6°C), young of year rearing; ≤62.6°F (18°C), late season rearing (primarily spring-run) Critical: 64.4 – 70°F (18-21.1°C) Lethal: >75 °F (23.9°C), prolonged exposure											
Floodplain Rearing*	Optimal: 55 – 68°F (13 – 20°C), unlimited food supply											
Outmigration	Optimal: ≤60°F (15.6°C) Critical: 64.4 – 70°F (18 – 21.1°C) Lethal: >75°F (23.9°C), prolonged exposure											

Sources: EPA 2003, Rich 2007, Pagliughi 2008, Gordus 2009.

Millerton Reservoir



Capacity ~ 520,500 AF

Right Temperature, Right Time

- Critical Elements:
  - A spring pulse to move juveniles downstream
  - Enough cold water for adults to over summer, and maintain temperatures for egg incubation
- Filling of the cold water pool
  - Timing of inflow indicates final temperature of cold water pool
  - High inflow years with flood releases "flush" the cold water pool

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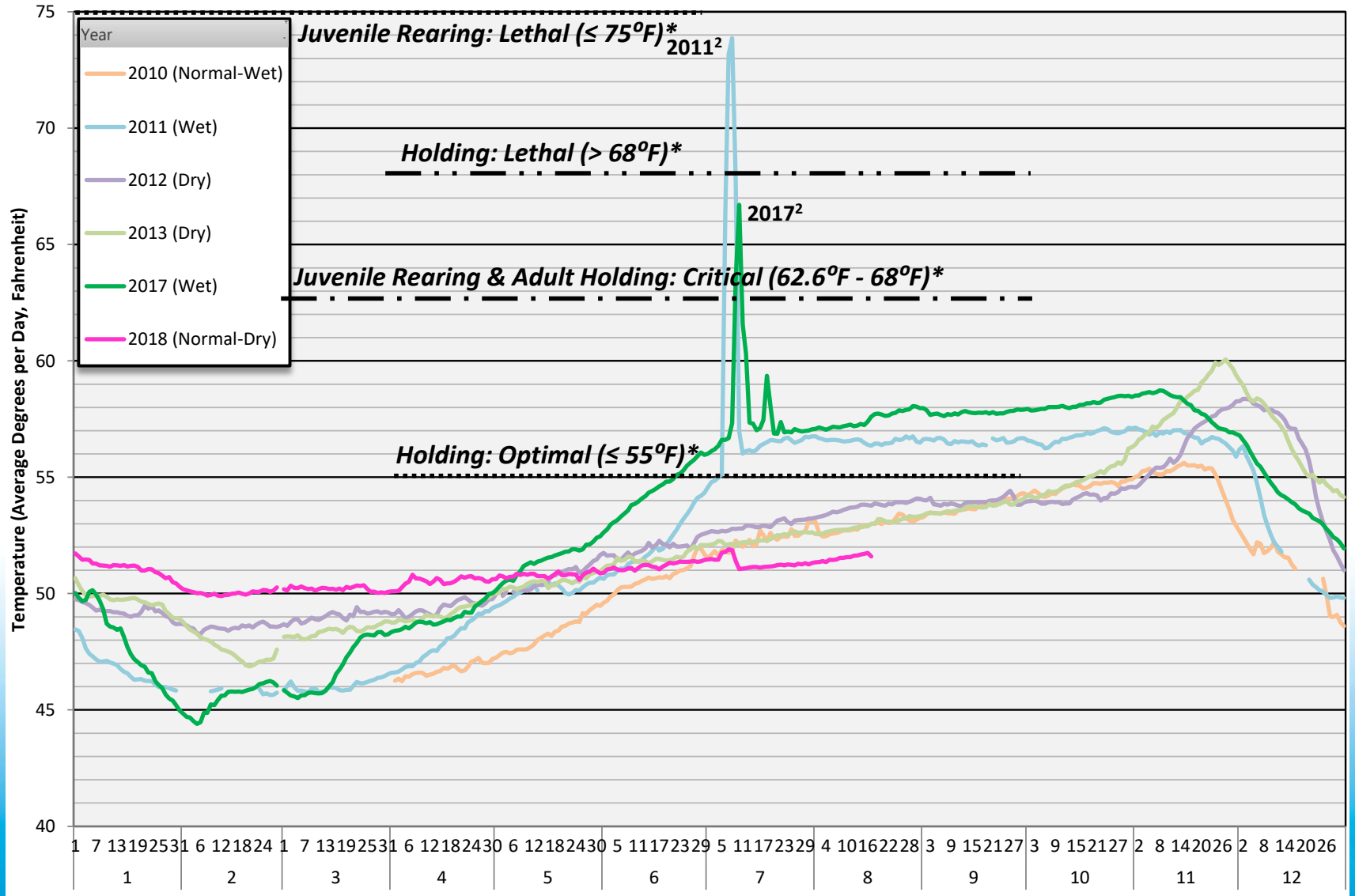
Flood years



² - Spillway Releases during Wet water year types (i.e. 2011, 2017).

* Adult Holding Temperature Objectives, Spring-Run Only (FMP, 2010).

Water Temperature Management

Summary

- Understanding the timing of snowmelt allows prioritization of objectives
- Limited control of temperature in wet years, but better forecasts allow you to:
  - Take reservoir management actions early
  - Prevent unnecessary flood releases from river outlet
  - Manage overtopping

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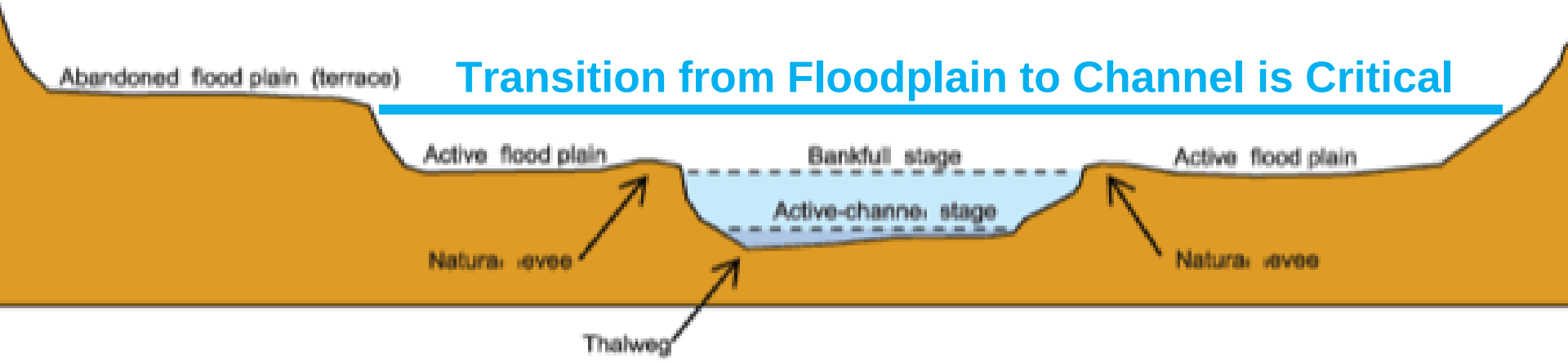
3 FLOOD FLOW RAMP-DOWN

Flood Flow Ramp-Down

- Flood flows are managed for the protection of life and property, environmental objectives may also be achieved
- Natural hydrograph recession ~ 5% flow reduction per day
- How reservoirs “ramp-down” is important ecologically



Flood Flow Ramp-Down

Riparian vegetation provides shade, cover, and food for fish

Floodplains are where juvenile salmon grow best

Flood Flow Ramp-Down

How do we manage flows for our limited floodplains?

1) Reduce Fish Stranding

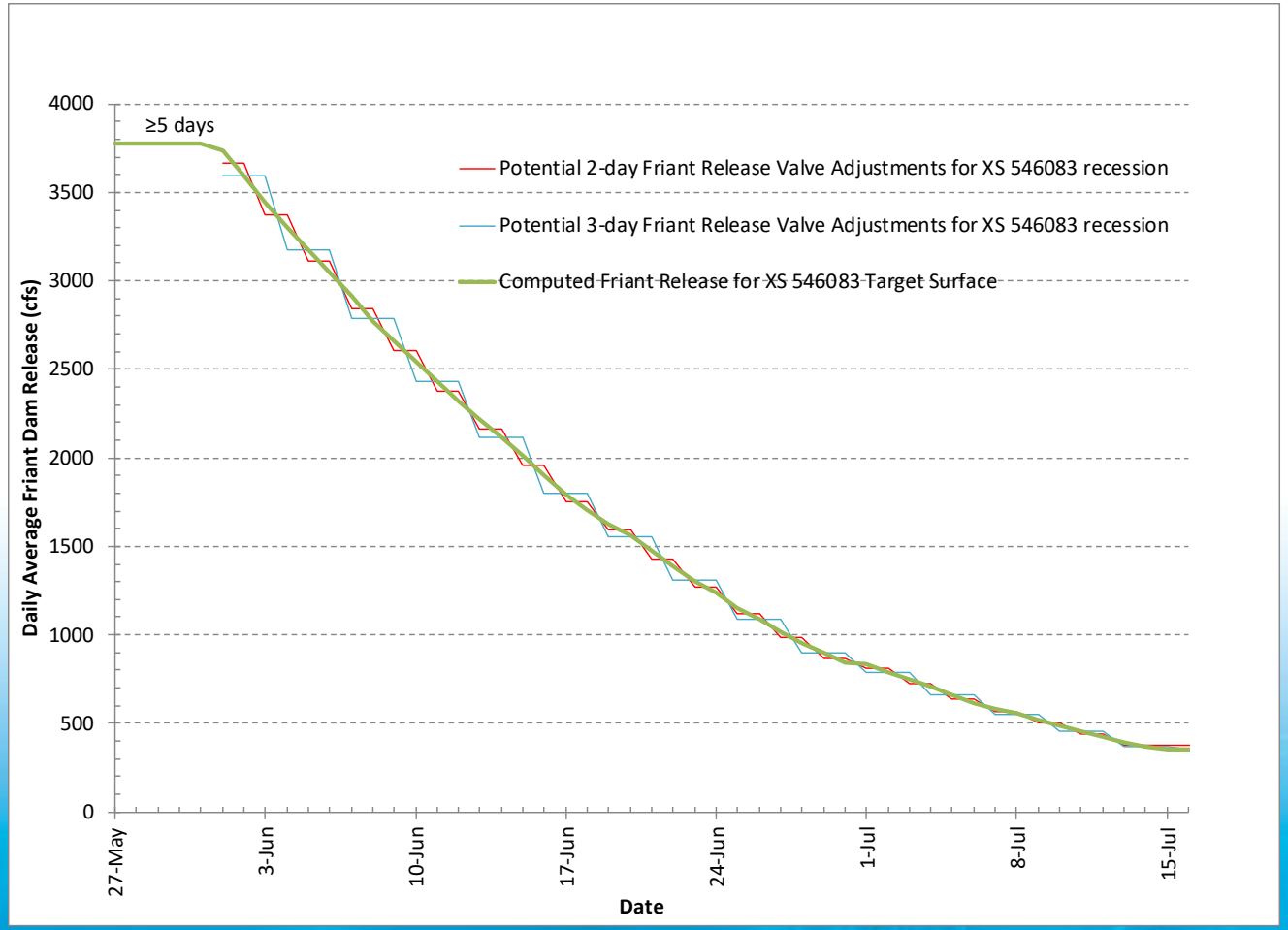
- Gradual ramp-down prevents juvenile salmon from getting stuck on a drying floodplain
- Maximum stage reduction rate depends on floodplain topography

2) Recruit Riparian Vegetation

- Gradual ramp-down provides suitable surface for germination and rooting of vegetation
- ~ 2.5 cm/day reduction in river stage

Riparian Vegetation Recruitment

Idealized ramp-down



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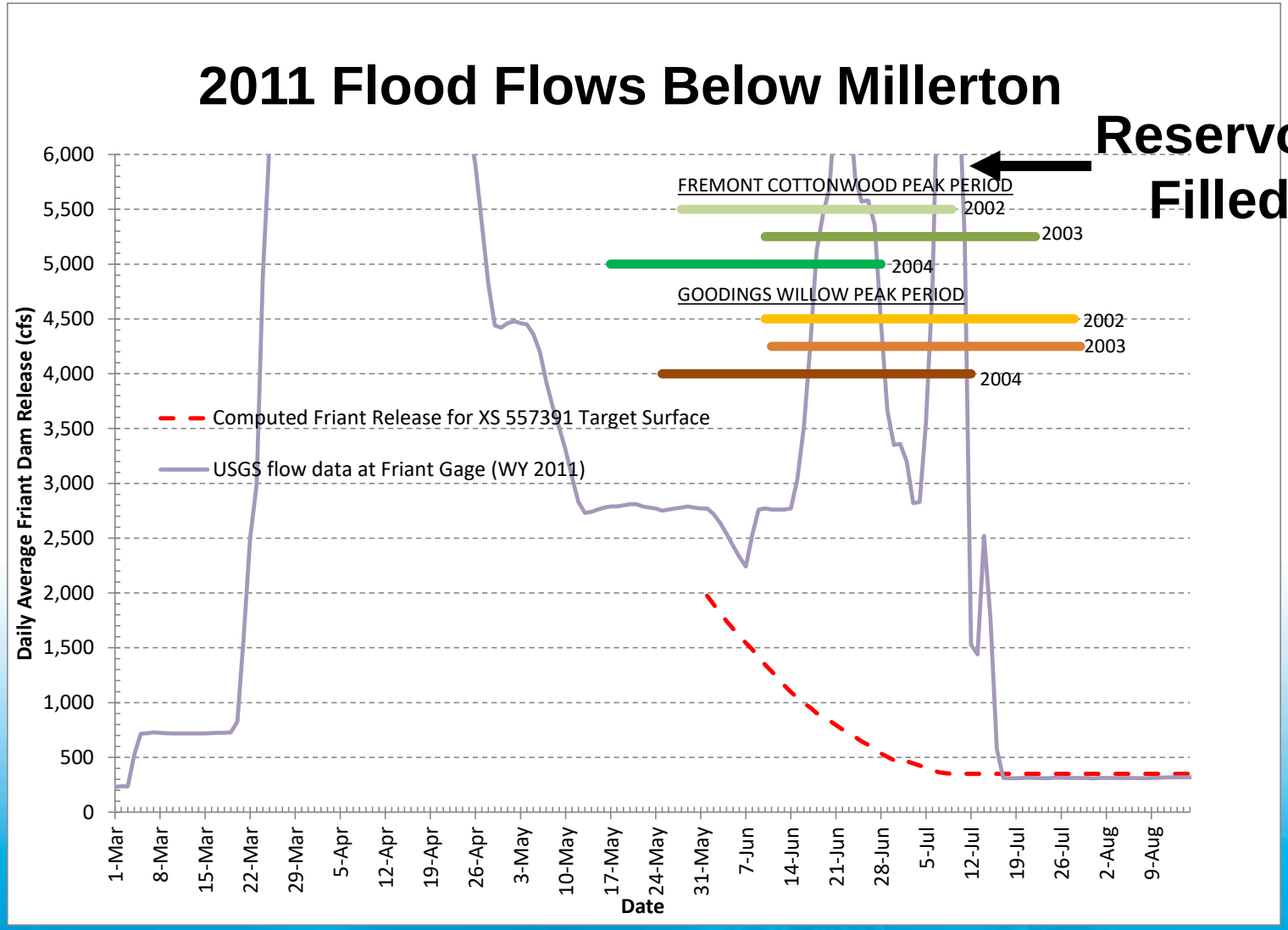
Riparian Vegetation Recruitment



Ramp-down Template

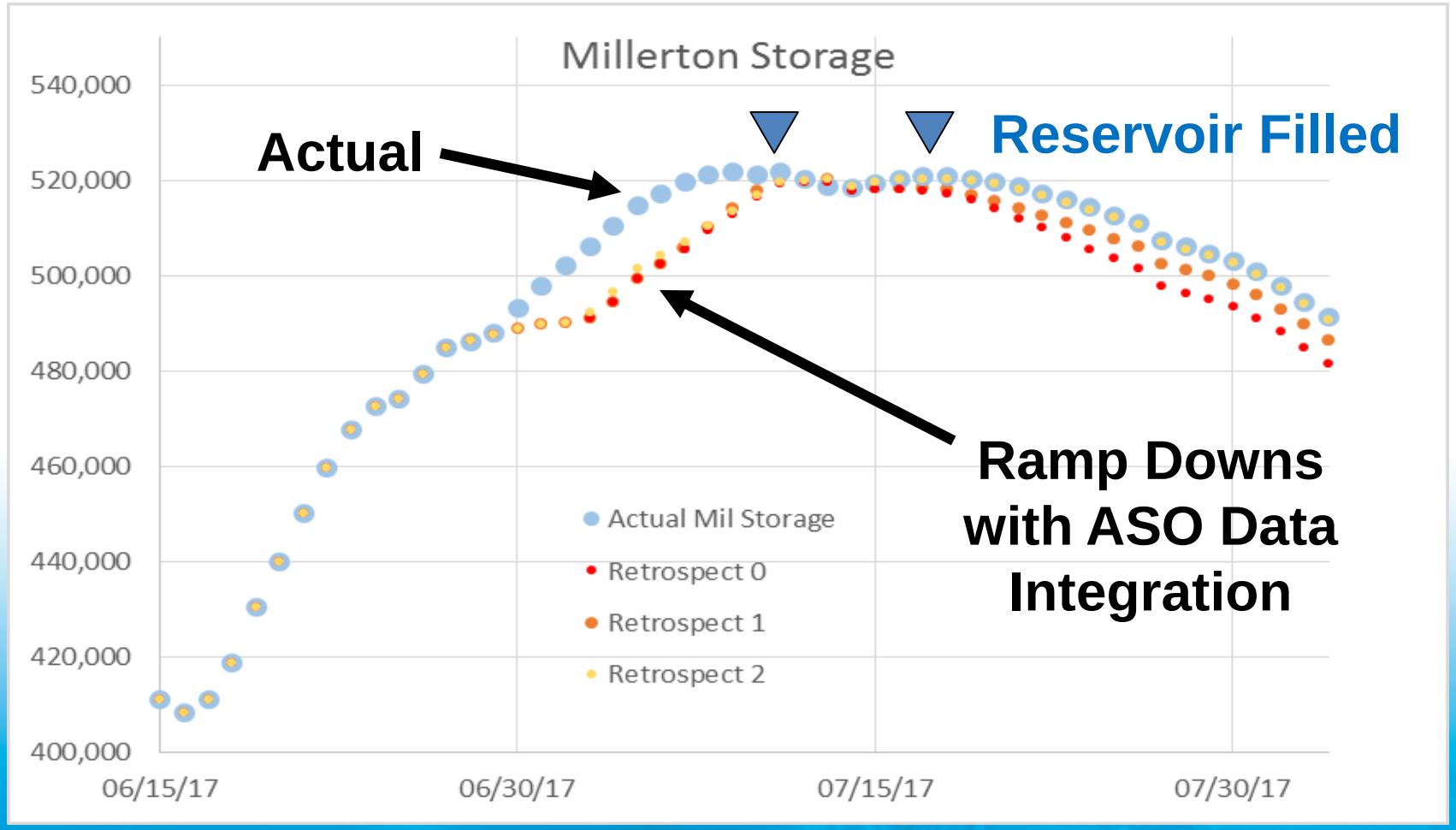
Can these ramp-downs be implemented with little to no impact other water users?

Yes, if:

- Runoff forecast is accurate (volume and timing) as reservoir reaches capacity
- Ramp-down begins BEFORE reservoir has filled

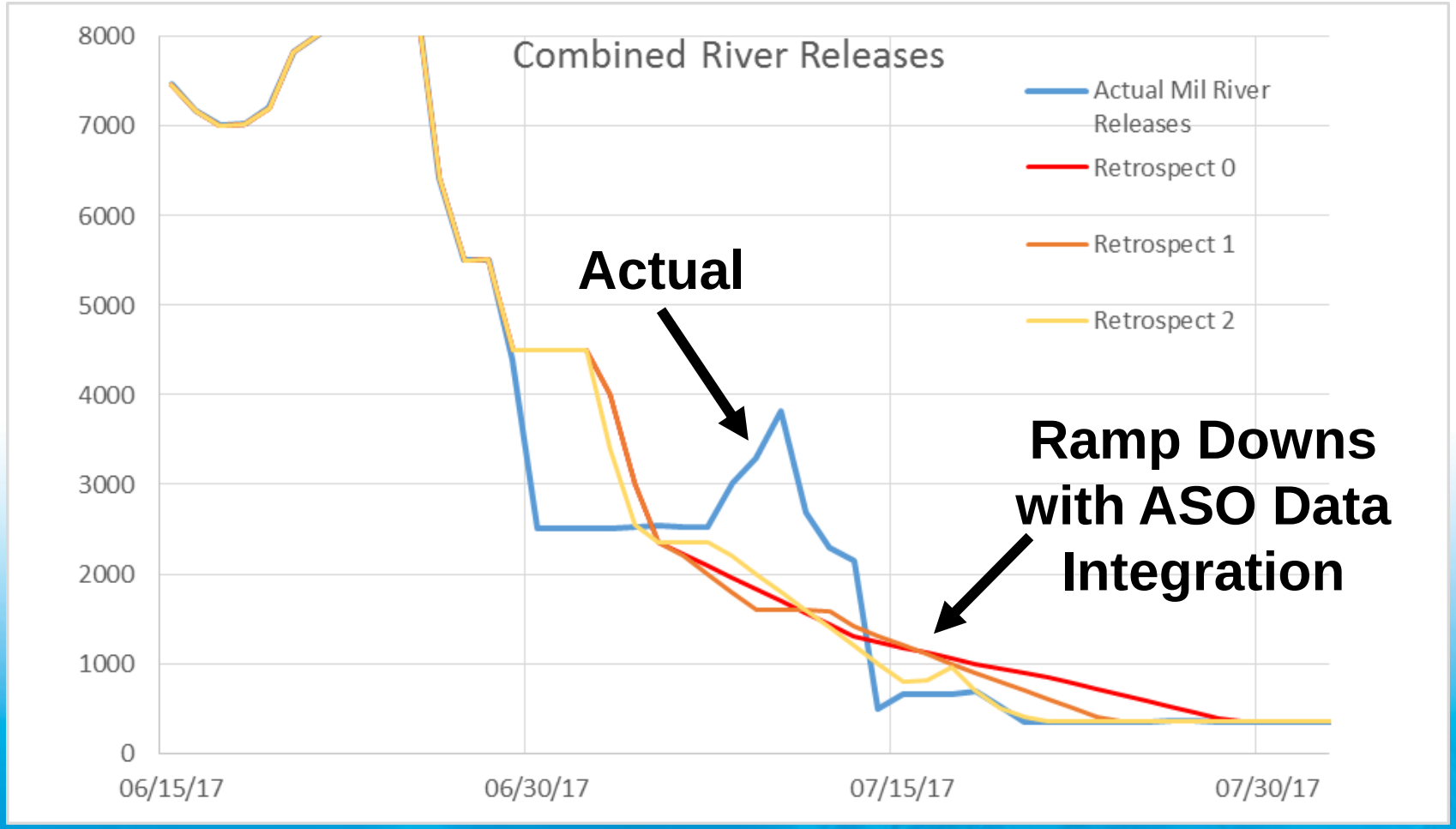
Retrospective Assessment

2017 Reservoir Storage Re-analysis



Retrospective Assessment

2017 San Joaquin River Flows Re-analysis



Flood Flow Ramp-Downs

Summary

- With a high level of forecast accuracy, gradual ramp-downs for riparian vegetation recruitment can be executed with little impact to residual water supply
- With a moderate level of forecast accuracy, ramp-downs to prevent juvenile salmon stranding can likewise be executed

Short-term runoff forecasts near time of reservoir filling are critical to floodplain management

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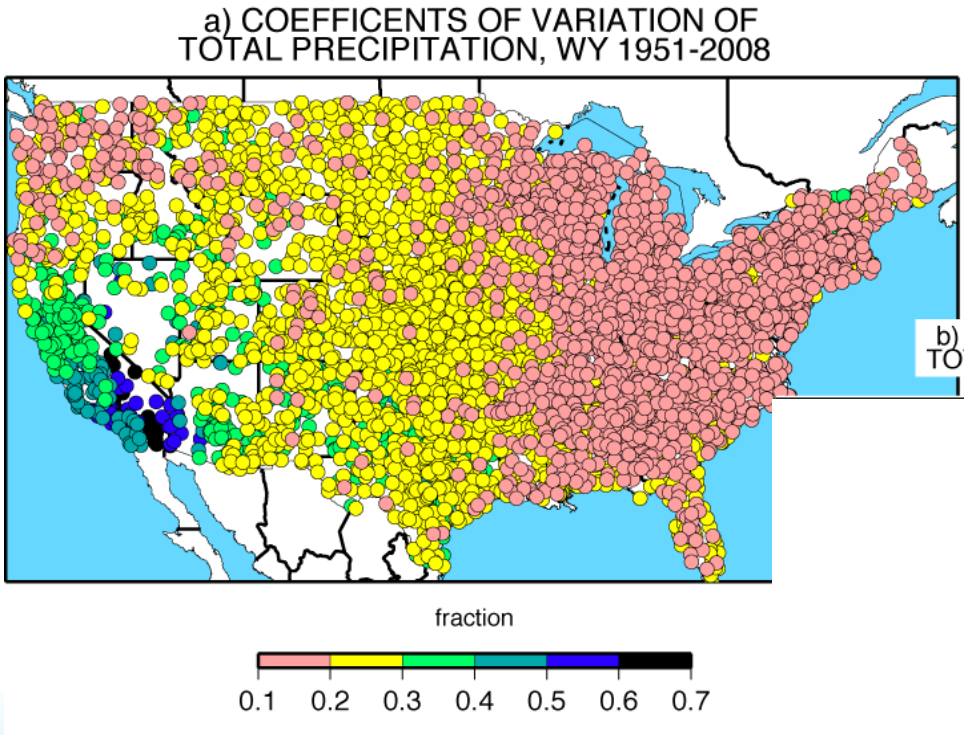
4 GROUNDWATER MANAGEMENT

Sustainable Groundwater

- Precipitation variability encourages groundwater use during drought

- Sustainability achieved through groundwater recharge in wet years – aquifer as a reservoir – or “conjunctive use”



Dettinger et. al 2011

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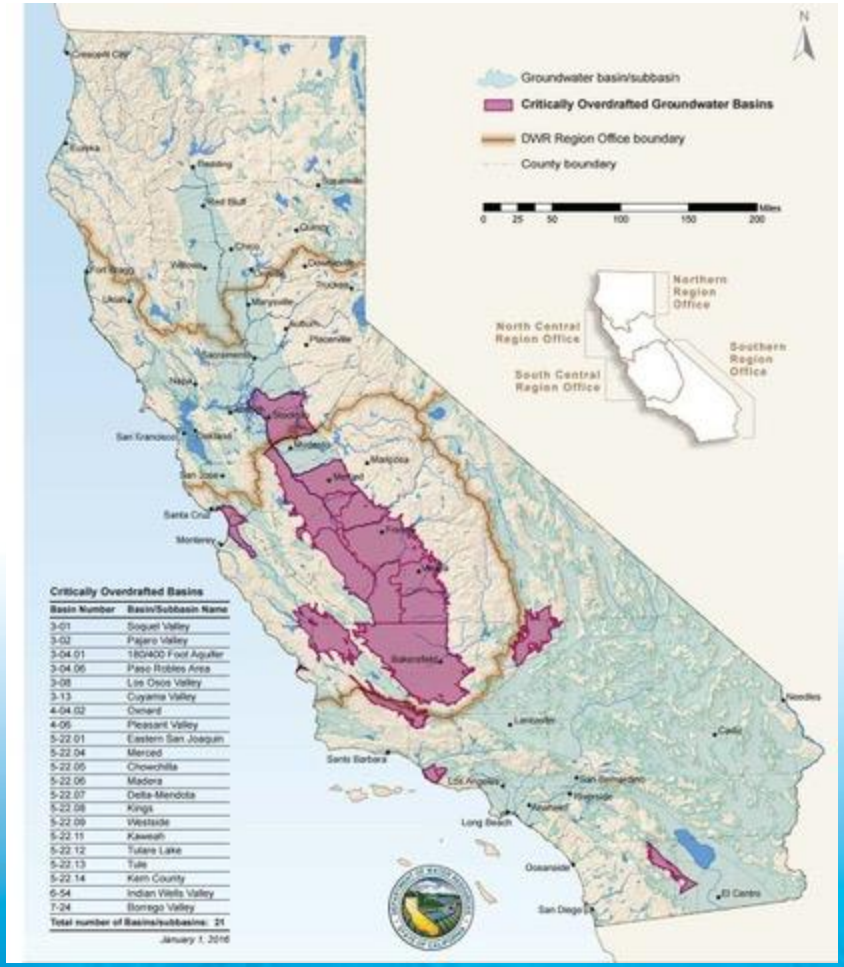
Sustainable Groundwater

SGMA - Sustainable Groundwater Management Act (CA-2014)

- Approved Sustainability Plans for critical basins due in 2020
- Groundwater balance must be demonstrated by 2040



Critical Overdraft Basins

Groundwater Recharge

- Recharge basins are being constructed where soils are favorable in the San Joaquin Valley
- Recharge volume limited by conveyance capacity, recharge rate, and price per acre-foot

Kimberlina Recharge Basin
Shafter-Wasco Irrigation District

Groundwater Recharge

Summary:

It is critical to have early confirmation of how much water is unstoreable

- Lower price
- Utilize canal capacity when it is not being used for irrigation

Kimberlina Recharge Basin
Shafter-Wasco Irrigation District

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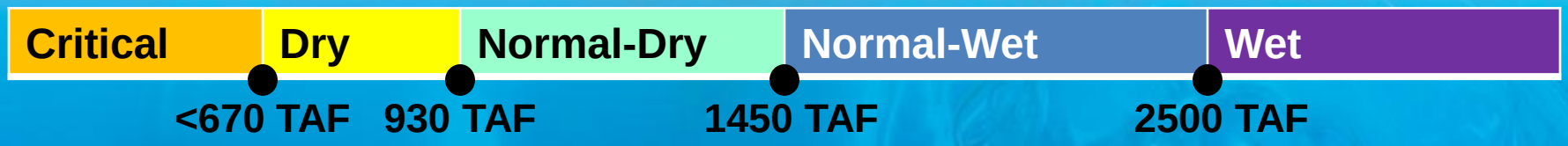
Summary Table

Environmental Flow Factor	Important Water Years	Important Timing	Ideal Runoff Forecast Accuracy
1) Restoration Flow Scheduling	Critical through Normal-Wet	Mar	+/- 50 TAF WY in Critical and Dry conditions, otherwise +/- 100 TAF WY (90% exceedance)
2) Water Temperature Management	Normal-Dry through Wet	Mar – May	Monthly runoff +/- 100 TAF
3) Flood Flow Ramp-Down	Normal-Wet, Wet	May – Jul	Monthly runoff +/- 50 TAF
4) Groundwater Management	Normal-Wet, Wet	Jan – Mar	Certainty that runoff will exceed reservoir storage



Conclusion

What does better runoff forecast accuracy and timing buy you?

1. More effective conjunctive use of water
2. Less anxiety among stakeholders
3. More successful river restoration
4. Less impact to water users from environmental flows
5. Adaptation to a changing climate